REMARKS

1. In paragraph 2 of the Official Action, the Examiner indicates that the Stephen B. Wicker document has not been considered. The Applicant notes that this document is an entire book and acknowledges that the Examiner has not taken it into consideration.

2. In paragraph 4 of the Official Action, the Examiner suggests that a number of claimed features were not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor, at the time the application was filed, had possession of the claimed invention. In reply, the Applicant submits that those features were disclosed in the specification as filed.

Arguments in relation to each of the claimed features appear below:

(a) *"the map of the geographic area and the coded data being printed substantially simultaneously":*

(i) In Figure 1 and on page 10, lines 6 to 11 of the specification, *"netpages"* are described as including both coded data and graphic data:

> *"As illustrated in Figure 1, a printed netpage 1 can represent a interactive form which can be filled in by the user both physically, on the printed page, and "electronically", via communication between the pen and the netpage system. The example shows a "Request" form containing name and address fields and a submit button. The netpage consists of graphic data 2 printed using visible ink, and coded data 3 printed as a collection of tags 4 using invisible ink."*

(ii) On page 10, lines 22 to 26 of the specification, the netpage printer 601 is described as printing netpages:

> *"The netpage printer 601, preferred forms of which are described in our earlier application USSN 09/575,155 (docket no. NPP003US) and our co-filed application USSN 09/693,514 (docket no. NPS024US), is able to deliver, periodically or on demand, personalized newspapers, magazines, catalogs, brochures and other publications, all printed at high quality as interactive netpages."*
>
> Additional disclosure of the manner in which netpage printers encode and print the coded data contained in netpages, can be found in cross-

referenced United States patent application No. 09/575,109 (PEC02US).

(iii) Since *"netpages"* include both coded data and graphic data and since the netpage printer 601 is described as printing netpages, one of ordinary skill in the art would understand that the netpage printer is described as printing both the coded data and the graphic data substantially simultaneously.

(iii) In Figure 14 and on page 24, lines 15 to 18 of the specification the netpage printer is described as printing netpages in which the *"graphic data"* takes the form of maps of countries, regions, cities and areas.

> *"If the user selects a point on a map or globe and clicks the <Print Country Map> button, a map 524 of the selected country is printed. The user may also print a map 524 of the selected location (country, region, or city) by clicking the <Print Map> button on the Information page, as shown in Figure 14."*

(iv) Since maps of countries, regions, cities and areas are maps of *"geographic areas"* and since the netpage printer is described as printing netpages containing such maps of geographic areas, one of ordinary skill in the art would understand that the method being described involves *"the map of the geographic area and the coded data being printed substantially simultaneously."*

(v) For these reasons, the Applicant submits that *"the map of the geographic area and the coded data being printed substantially simultaneously"* was in the specification as filed and asks that the Examiner withdraw this objection.

(b) *"generating the indicating data based at least partially on sensing at least some of the coded data in the vicinity of the position"*:

(i) Page 13, line 28 to page 14 line 3 of the specification describes the netpage pen as generating the page identifier and position of the pen relative to the page (the indicating data) by sensing the tags (coded data) even on a single click on the page (in the vicinity of the position of the sensing device):

> *"A tag is sensed by an area image sensor in the netpage pen, and the tag data is transmitted to the netpage system via the nearest netpage printer. The pen is wireless and communicates with the netpage*

printer via a short-range radio link. Tags are sufficiently small and densely arranged that the pen can reliably image at least one tag even on a single click on the page. It is important that the pen recognize the page ID and position on every interaction with the page, since the interaction is stateless."

(ii) The netpage pen is therefore described as *"generating the indicating data based at least partially on sensing at least some of the coded data in the vicinity of the position."*

(iii) For this reason, the Applicant submits that *"generating the indicating data based at least partially on sensing at least some of the coded data in the vicinity of the position"* was in the specification as filed and asks that the Examiner withdraw this objection.

(c) *"the printer being adapted to print the map and the coded data substantially simultaneously":*

(i) The arguments and specification extracts mentioned in paragraph (a) of this section apply equally to this claim feature.

(d) *"comprising a non-electronic printed surface displaying coded data indicative of a plurality of reference points of the globe":*

(i) Page 20, lines 29 and 30 describe a globe printed as a netpage:

"The surface of a globe (i.e. a sphere representing the earth) can also be printed as a netpage."

Further disclosure of netpage tags being applied to a spherical surface, such as a globe, can be found in cross-referenced United States patent application No. US 09/575,129 (NPT002) in the section entitled *"8.1.2 Spherical Surface Tag Tiling"* beginning at the end of page 74.

(ii) Page 9, lines 25 to 27 describe netpages as being printed on ordinary paper:

"In its preferred form, the netpage system relies on the production of, and human interaction with, netpages. These are pages of text, graphics and images printed on ordinary paper or other media, but which work like interactive web pages."

(iii) *"Ordinary paper"* is a non-electronic surface.

(iv) Since these passages disclose a globe printed as a netpage, and since a netpage is a non-electronic printed surface, these passages disclose a globe *"comprising a non-electronic printed surface displaying coded data indicative of a plurality of reference points of the globe."*

(v) For these reasons, the Applicant submits that a globe *"comprising a non-electronic printed surface displaying coded data indicative of a plurality of reference points of the globe"* was in the specification as filed and asks that the Examiner withdraw this objection.

3. In order to more clearly distinguish the claimed invention from the cited art, the Applicant has sought to delete claims 1 to 5, 7 and 12 and to amend independent claims 6 and 11. The Applicant submits that independent claim 6 is novel and inventive in light of the cited art for the following reasons:

(a) Neither Dymetman nor Conroy et al disclose a printer *"adapted to print the map and the coded data substantially simultaneously."* In paragraph 6 of the Official Action the Examiner acknowledges that Conroy et al. *"fails to specifically disclose printing a map, including coded data; the map of the geographic area and the coded data being printed substantially simultaneously."* The Examiner argues, however that these feature are disclosed on page 396, section 3 of the Dymetman article. The Applicant concedes that the map of Europe disclosed in the Dymetman article is printed with two layers of ink, one being the coded layer and the other being the conventional, visible layer. However, the Dymetman article does not disclose that these two layers are printed *substantially simultaneously*. In contrast, the following sentences from the Dymetman article teach that the coded layer of ink in the Dymetman arrangement is pre-printed by an authorised producer and the layer of conventional, visible ink is added later by a publisher:

> *"These sheets are produced by publishers, who buy apparently blank sheets of Intelligent Paper from an authorized producer. The publishers can mark them with conventional visible inks in any way they choose."* (Page 394, lines 1 to 3)

"This way of proceeding exploits the natural tendency of publishers to buy Intelligent Paper sheets in bulk, so that it may be known by the first router that a certain number of consecutive page-ids are "owned" by a certain publisher." (Page 398, lines 4 to 7)

In addition, as at the date of the invention, the state of printer technology was such that one of ordinary skill in the art would not have readily conceived of a printer capable of printing both layers of ink simultaneously, given the complex nature of the coded data layer. However, the Applicant's invention does disclose printing technology capable of such simultaneous printing.

(b) Neither of the citations disclose a sensing device having the features defined in amended claim 6. The sensing device in the Conroy et al arrangement does not have an image sensor at all. In Dymetman, although there is some disclosure on how the *"pointer"* might be used, there is no disclosure of how it works. In fact, the text suggests that the *"writer-pointer"* had not even been developed at the time of writing. For example, on page 404 under the heading *"6 Conclusion"* the Dymetman article reads:

"We have discussed some of the potential applications of Intelligent Paper, and presented the underlying technology in its broad outline. Some aspects of this technology – invisible ink, writer–pointer – are not fully mature yet, but progress is being rapidly made."

There is certainly no disclosure in either Dymetman or Conroy of a sensing device which has a processor which is adapted to:

"(i) identify at least some of the coded data from one or more of the captured images;

(ii) determine an orientation, within the captured images, of at least some of the coded data;

(iii) decode at least some of the coded data; and

(iv) generate, using at least some of the decoded coded data, indicating data indicative of the identity of the map and a position of the sensing device relative to the map"

Claim 6 is therefore not anticipated by the Dymetman and Conroy citations. Similar comments apply in relation to claim 11.

4. In anticipation of the examiner questioning where in the specification these features of the sensing device are disclosed, the Applicant makes the following comments:

(a) On page 10, lines 17 to 21 of the specification as filed, the reader is referred to one of the Applicant's co-pending applications for further details on the sensing device:

> *"As illustrated in Figure 2, the netpage pen 101, a preferred form of which is described in our earlier application USSN 09/575,174 (docket no. NPS001US), works in conjunction with a netpage printer 601, an Internet-connected printing appliance for home, office or mobile use. The pen is wireless and communicates securely with the netpage printer via a short-range radio link 9."*

(b) In the Applicant's co-pending application USSN 09/575,174, the Netpage pen is described in significant detail. In support of these claim amendments, the Examiner is particularly referred to the following sections of that document:

(i) page 65, line 18 to page 66 line 11 under the heading *"6.4 Pen Processing";* and

(ii) page 62 line 7 to page 64 line 14 under the heading *"6.2 Pen Controller."*

For the Examiner's ease of reference, pages 62 to 66 of USSN 09/575,174 are attached.

5. For the above reasons the Applicant submits that amended claims 6 and 8 to 11 are novel and inventive in light of the cited art and that the claim amendments introduce no new matter.

CONCLUSION

It is respectfully submitted that all of the Examiner's objections have been successfully traversed. Accordingly, it is submitted that the application is now in condition for allowance. Reconsideration and allowance of the application is courteously solicited.

Very respectfully,

Applicant:

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

CO-PENDING APPLICATIONS

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention on October 20, 2000:

09/693,415 ~~(NPA011US)~~, 09/693,219 ~~(NPA031US)~~, 09/693,280 ~~(NPA040US)~~,
09/693,515 ~~(NPA046US)~~, 09/693,705 ~~(NPA053US)~~, 09/693,647 ~~(NPA059US)~~,
09/693,690 ~~(NPA064US)~~, 09/693,593 ~~(NPB006US)~~, 09/693,216 ~~(NPS004US)~~,
09/693,341 ~~(NPS008US)~~, 09/696,473 ~~(NPS013US)~~ 09/696,514 ~~(NPS024US)~~,
09/693,301 ~~(NPPC1)~~, 09/693,388 ~~(UP01US)~~, 09/693,704 ~~(UP02US)~~,
09/693,510 ~~(UP03US)~~, ~~09/~~09/693,336 ~~(UP04US)~~, 09/693,335 ~~(UP05US)~~

The disclosures of these co-pending applications are incorporated herein by reference.

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention on September 15, 2000:

09/663,579 ~~(NPA024US)~~, 09/669,599 ~~(NPA025US)~~, 09/663,701 ~~(NPA047US)~~,
09/663,640 ~~(NPA049US)~~,

The disclosures of these co-pending applications are incorporated herein by reference.

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention on June 30, 2000:

09/609,139 ~~(NPA014US)~~, 09/608,970 ~~(NPA015US)~~, 09/609,039 ~~(NPA022US)~~,
09/607,852 ~~(NPA026US)~~, 09/607,656 ~~(NPA038US)~~, 09/609,132 ~~(NPA041US)~~,
09/609,303 ~~(NPA050US)~~, 09/610,095 ~~(NPA051US)~~, 09/609,596 ~~(NPA052US)~~,
09/607,843 ~~(NPA063US)~~, 09/607,605 ~~(NPA065US)~~, 09/608,178 ~~(NPA067US)~~,
09/609,553 ~~(NPA068US)~~, 09/609,233 ~~(NPA069US)~~, 09/609,149 ~~(NPA071US)~~,
09/608,022 ~~(NPA072US)~~, 09/609,232 ~~(NPB003US)~~, 09/607,844 ~~(NPB004US)~~,
09/607,657 ~~(NPB005US)~~, 09/608,920 ~~(NPP019US)~~, 09/607,985 ~~(PEC04US)~~,
09/607,990 ~~(PEC05US)~~, 09/607,196 ~~(PEC06US)~~, 09/606,999 ~~(PEC07US)~~

The disclosures of these co-pending applications are incorporated herein by reference.

Various methods, systems and apparatus relating to the present invention are disclosed in the following co-pending applications filed by the applicant or assignee of the present invention on 23 May 2000:

09/575,197 ~~(NPA001US)~~, 09/575,195 ~~(NPA002US)~~, 09/575,159 ~~(NPA004US)~~,
09/575,132 ~~(NPA005US)~~, 09/575,123 ~~(NPA006US)~~, 09/575,148 ~~(NPA007US)~~,
09/575,130 ~~(NPA008US)~~, 09/575,165 ~~(NPA009US)~~, 09/575,153 ~~(NPA010US)~~,
09/575,118 ~~(NPA012US)~~, 09/575,131 ~~(NPA016US)~~, 09/575,116 ~~(NPA017US)~~
09/575,144 ~~(NPA018US)~~, 09/575,139 ~~(NPA019US)~~, 09/575,186 ~~(NPA020US)~~,
09/575,185 ~~(NPA021US)~~, 09/575,191 ~~(NPA030US)~~, 09/575,145 ~~(NPA035US)~~,
09/575,192 ~~(NPA048US)~~, 09/575,181 ~~(NPA075US)~~, 09/575,193 ~~(NPB001US)~~,
09/575,156 ~~(NPB002US)~~, 09/575,183 ~~(NPK002US)~~, 09/575,160 ~~(NPK003US)~~,
09/575,150 ~~(NPK004US)~~, 09/575,169 ~~(NPK005US)~~, 09/575,184 ~~(NPM001US)~~,
09/575,128 ~~(NPM002US)~~, 09/575,180 ~~(NPM003US)~~, 09/575,149 ~~(NPM004US)~~,
09/575,179 ~~(NPN001US)~~, 09/575,133 ~~(NPP005US)~~, 09/575,143 ~~(NPP006US)~~,
09/575,187 ~~(NPP001US)~~, 09/575,155 ~~(NPP003US)~~, 09/575,196 ~~(NPP007US)~~,
09/575,198 ~~(NPP008US)~~, 09/575178 ~~(NPP016US)~~, 09/575,164 ~~(NPP017US)~~,
09/575,146 ~~(NPP018US)~~, 09/575,174 ~~(NPS001US)~~, 09/575,163 ~~(NPS003US)~~,
09/575,168 ~~(NPS020US)~~, 09/575,154 ~~(NPT001US)~~, 09/575,129 ~~(NPT002US)~~,
09/575,124 ~~(NPT003US)~~, 09/575,188 ~~(NPT004US)~~, 09/575,189 ~~(NPX001US)~~,
09/575,162 ~~(NPX003US)~~, 09/575,172 ~~(NPX008US)~~, 09/575,170 ~~(NPX011US)~~,
09/575,171 ~~(NPX014US)~~, 09/575,161 ~~(NPX016US)~~, 09/575,141 ~~(IJ52US)~~,
09/575,125 ~~(IJM52US)~~, 09/575,142 ~~(MJ10US)~~, 09/575,140 ~~(MJ11US)~~,
09/575,190 ~~(MJ12US)~~, 09/575,138 ~~(MJ13US)~~, 09/575,126 ~~(MJ14US)~~,
09/575,127 ~~(MJ15US)~~, 09/575,158 ~~(MJ34US)~~, 09/575,117 ~~(MJ47US)~~,
09/575,147 ~~(MJ58US)~~, 09/575,152 ~~(MJ62US)~~, 09/575,176 ~~(MJ63US)~~,
09/575,115 ~~(PAK04US)~~, 09/575,114 ~~(PAK05US)~~, 09/575,113 ~~(PAK06US)~~,
09/575112 ~~(PAK07US)~~, 09/575,111 ~~(PAK08US)~~, 09/575,108 ~~(PEC01US)~~,
09/575,109 ~~(PEC02US)~~, 09/575,110 ~~(PEC03US)~~

The disclosures of these co-pending applications are incorporated herein by reference.

In the Claims:

Claims 6, 8, 9 and 11 have been amended as follows:

6. (Twice Amended) A system for enabling a user to designate, in a computer system, at least one geographic location, the system including:

a surface on which is disposed a map of a geographic area, the geographic area including the at least one geographic location, the map including coded data indicative of an

identity of the map and of a plurality of reference points of the map;

a printer for printing the map, including the coded data onto the surface, ~~on demand,~~ the printer being adapted to print the map and the coded data substantially simultaneously; ~~and~~

a sensing device comprising:

(a) an image sensor adapted to capture images of at least some of the coded data when the sensing device is placed in an operative position relative to the surface; and

(b) a processor adapted to:

(i) identify at least some of the coded data from one or more of the captured images;

(ii) determine an orientation, within the captured images, of at least some of the coded data;

(iii) decode at least some of the coded data; and

(iv) generate, using at least some of the decoded coded data, indicating data indicative of the identity of the map and a position of the sensing device relative to the map; and

a computer system configured to ~~for receiving~~ receive the indicating data from ~~a~~ the sensing device ~~operated by the user, the indicating data regarding the identity of the map and a position of the sensing device relative to the map, the sensing device, when placed in an operative position relative to the map, generating the indicating data based at least partially on sensing at least some of the coded data in the vicinity of the position;~~

~~wherein the computer system is configured~~ and to identify, from the indicating data, the at least one geographic location.

8. (Amended) A system according to claim ~~7~~ 6 wherein the map contains at least one of the following categories of map information:

(a) geographic features of the geographic area;

(b) cities in the geographic area;

(c) countries related to the geographic area;

(d) different views of the geographic area;

(e) topography of the geographic area;

(f) vegetation of the geographic area;

(g) average rainfall for the geographic area;

(h) seasonal temperatures for the geographic area; and

(i) population for the geographical area.

9. (Amended) A system according to claim 6 ~~or claim 7~~ further including a map control page including at least one printed map control; wherein the computer system is configured to perform an action associated with the map control when the map control is designated by the user using the sensing device.

11. (Twice Amended) A system for enabling a user to designate, in a computer system, at least one geographic location, the system including:

a globe having a surface on which is disposed a global map, the global map including the at least one geographic location and, ~~the globe comprising a non-electronic printed surface displaying~~ coded data indicative of a plurality of reference points of the globe;

a sensing device comprising:

(a) an image sensor adapted to capture images of at least some of the coded data when the sensing device is placed in an operative position relative to the globe; and

(b) a processor adapted to:

(i) identify at least some of the coded data from one or more of the captured images;

(ii) determine an orientation, within the captured images, of at least some of the coded data;

(iii) decode at least some of the coded data; and

(iv) generate, using at least some of the decoded coded data, indicating data indicative of a position of the sensing device relative to the globe; and

a computer system ~~for receiving~~configured to receive the indicating data from ~~a~~ the sensing device ~~operated by the user, the indicating data regarding a position of the sensing device relative to the surface of the globe, the sensing device, when placed in an operative position relative to the surface of the globe, generating~~and to ~~the indicating data based at least partially on sensing at least some of the coded data in the vicinity of the position;~~

ATTACHMENT REFERRED TO IN 4(B) OF REMARKS.

119 or stylus nib 121. The IR photodiode 144 detects light from the IR LED 143 via reflectors (not shown) mounted on the slider blocks 123 and 124.

Rubber grip pads 141 and 142 are provided towards the end 108 of the housing 102 to assist gripping the pen 101, and top 105 also includes a clip 142 for clipping the pen 101 to a pocket.

6.2 PEN CONTROLLER

The pen 101 is arranged to determine the position of its nib (stylus nib 121 or ink cartridge nib 119) by imaging, in the infrared spectrum, an area of the surface in the vicinity of the nib. It records the location data from the nearest location tag, and is arranged to calculate the distance of the nib 121 or 119 from the location tab utilising optics 135 and controller chip 134. The controller chip 134 calculates the orientation of the pen and the nib-to-tag distance from the perspective distortion observed on the imaged tag.

Control data from the location tag may include control bits instructing the pen 101 to activate its "active area" LED (this is in fact one mode of the tri-color LED 116, which becomes yellow when the pen determines, from the control data, that the area that is being imaged is an "active area"). Thus, a region on the surface which corresponds to the active area of a button or hyperlink may be encoded to activate this LED, giving the user of the pen visual feedback that the button or hyperlink is active when the pen 101 passes over it. Control data may also instruct the pen 101 to capture continuous pen force readings. Thus a region on the surface which corresponds to a signature input area can be encoded to capture continuous pen 101 force.

Pen 101 action relative to the surface may comprise a series of strokes. A stroke consists of a sequence of time-stamped pen 101 positions on the surface, initiated by pen-down event and completed by a subsequent pen-up event. Note that pen force can be interpreted relative to a threshold to indicate whether the pen is "up" or "down", as well as being interpreted as a continuous value, for example when the pen is capturing a signature. The sequence of captured strokes constitutes so-called "digital ink". Digital ink can be used with a computing system to form the basis for the digital exchange of drawings and handwriting, for on-line recognition of handwriting, and for on-line verification of signatures.

Utilising the RF chip 133 and antenna 112 the pen 101 can transmit the digital ink data (which is encrypted for security and packaged for efficient transmission) to the computing system.

When the pen is in range of a receiver, the digital ink data is transmitted as it is formed. When the pen 101 moves out of range, digital ink data is buffered within the pen 101 (the pen 101 circuitry includes a buffer arranged to store digital ink data for approximately 12 minutes of the pen motion on the surface) and can be transmitted later.

The controller chip 134 is mounted on the second flex PCB 129 in the pen 101. Figure 10 is a block diagram illustrating in more detail the architecture of the controller chip 134. Figure 10 also shows representations of the RF chip 133, the image sensor 132, the tri-color status LED 116, the IR illumination LED 131, the IR force sensor LED 143, and the force sensor photodiode 144.

The pen controller chip 134 includes a controlling processor 145. Bus 146 enables the exchange of data between components of the controller chip 134. Flash memory 147 and a 512 KB DRAM 148 are also included. An analog-to-digital converter 149 is arranged to convert the analog signal from the force sensor photodiode 144 to a digital signal.

An image sensor interface 152 interfaces with the image sensor 132. A transceiver controller 153 and base band circuit 154 are also included to interface with the RF chip 133 which includes an RF circuit 155 and RF resonators and inductors 156 connected to the antenna 112.

The controlling processor 145 captures and decodes location data from tags from the surface via the image sensor 132, monitors the force sensor photodiode 144, controls the LEDs 116, 131 and 143, and handles short-range radio communication via the radio transceiver 153. It is a medium-performance (~40MHz) general-purpose RISC processor.

The processor 145, digital transceiver components (transceiver controller 153 and baseband circuit 154), image sensor interface 152, flash memory 147 and 512KB DRAM 148 are integrated in a single controller ASIC. Analog RF components (RF

circuit 155 and RF resonators and inductors 156) are provided in the separate RF chip.

The image sensor is a 215x215 pixel CCD (such a sensor is produced by Matsushita Electronic Corporation, and is described in a paper by Itakura, K T Nobusada, N Okusenya, R Nagayoshi, and M Ozaki, "A 1mm 50k-Pixel IT CCD Image Sensor for Miniature Camera System", IEEE Transactions on Electronic Devices, Volt 47, number 1, January 2000, which is incorporated herein by reference) with an IR filter.

The controller ASIC 134 enters a quiescent state after a period of inactivity when the pen 101 is not in contact with a surface. It incorporates a dedicated circuit 150 which monitors the force sensor photodiode 144 and wakes up the controller 134 via the power manager 151 on a pen-down event.

The radio transceiver communicates in the unlicensed 900MHz band normally used by cordless telephones, or alternatively in the unlicensed 2.4GHz industrial, scientific and medical (ISM) band, and uses frequency hopping and collision detection to provide interference-free communication.

6.3 PEN OPTICS

As discussed above, the pen 101 optics is implemented by a moulded optics body 135. The optics that is implemented by the optics body 135 is illustrated schematically in Figure 48. The optics comprises a first lens 157 for focussing radiation from the infrared LED 131, a mirror 158, a beam splitter 159, an objective lens 160 and a second lens 161 for focusing an image onto image sensor 132. Axial rays 162 illustrate the optical path.

The optical path is designed to deliver a sharp image to the image sensor 132 of that part 193 of the imaged surface which intersects the field of view cone 192, within required tilt ranges (see later). The primary focussing element is the objective lens 160. This is also used in reverse to project illumination from the IR illumination LED 131 onto the surface within the field of view. Since it is impractical to place both the image sensor 132 and the IR LED 131 at the focus of the objective, a beam splitter 159 is used to split the path and separate relay lenses 157 and 161 in each path provides refocussing at the image sensor 132 and the IR LED 131 respectively. This also allows different apertures to be imposed on the two paths.

The edges of the image sensor 132 act as the field stop for the capture field, and the capture path is designed so that the resulting object space angular field of view is as required (i.e. just under 20° for the application of this embodiment). The illumination path is designed to produce the same object space field of view as the capture path, so that the illumination fills the object space field of view with maximum power and uniformity.

The IR LED 131 is strobed in synchrony with frame capture. The use of focussed illumination allows both a short exposure time and a small aperture. The short exposure time prevents motion blur, thus allowing position tag data capture during pen movement. The small aperture allows sufficient depth of field for the full range of surface depths induced by tilt. The capture path includes an explicit aperture stop 191 for this purpose.

Because the image sensor 132 has a strong response throughout the visible and near infrared part of the spectrum, it is preceded by an infrared filter 163 in the capture path so that it captures a clean image of the tag data on the surface, free from interference from other graphics on the surface which may be printed using inks which are transparent in the near infrared.

6.4 PEN PROCESSING

When the stylus nib 121 or ink cartridge nib 119 of the pen 101 is in contact with a surface, the pen 101 determines its position and orientation relative to the surface at 100 Hz to allow accurate handwriting recognition (see the article by Tappert, C, C Y Suen and T Wakahara, "The State of the Art in On-Line Hand Writing Recognition" IEEE Transactions on Patent Analysis and Machine Intelligence, Vol 12, number 8, August 1990, the disclosure of which is incorporated herein by cross-reference). The force sensor photodiode 144 is utilised to indicate relative threshold whether the pen is "up" or "down". The force may also be captured as a continuous value, as discussed above, to allow the full dynamics of a signature to be verified.

The pen 101 determines the position and orientation of its nib 119, 121 on the surface by imaging, in the infrared spectrum, an area of the surface in the vicinity of the nib 119, 121. It decodes the nearest tag data and computes the position of the nib 119, 121 relative to the location tag from the observed perspective distortion on the imaged

tag and the known geometry of the pen optics 135 (see later). Although the position resolution of the tag may be low, the adjusted position resolution is quite high, and easily exceeds the 200 dpi resolution required for accurate handwriting recognition (see above reference).

Pen 101 actions relative to a surface are captured as a series of strokes. A stroke consists of a sequence of time-stamped pen positions on the surface, initiated by a pen-down event and completed by the subsequent pen-up event. A stroke is also tagged with the region ID of the surface whenever the region ID changes, i.e. just at the start of the stroke under normal circumstances. As discussed above, each location tag includes data indicative of its position on the surface and also region data indicative of the region of the surface within which the tag lies.

Figure 49 is a diagram illustrating location tag and stroke processing in the pen 101. When the pen 101 is in the pen-up state, the pen controller 134 continuously monitors the force sensor photodiode 144 for a pen-down condition (step 164). While the pen is in a pen-down state, the pen controller 134 continuously captures 165, 166 and decodes 167 tag data from location tags from the surface, infers the pen 101 position and orientation relative to the surface, 168 and appends the position data to the current stroke data (including the tag data and other information such as force, if it is being continuously monitored). On a pen-up event the pen controller 134 encrypts 170 the stroke data and transmits 171 the stroke data via the RF chip 133 and antenna 112, to the computing system. Note that the pen samples the nib force 172 in order to determine whether the stroke has been completed 173 and also to determine whether a new stroke is being started 174.

Assuming a reasonably fast 8 bit multiply (3 cycles), the processing algorithm (see later) uses about 80% of the processor's time when the pen is active.

If the pen is out of range of a computing system to transmit to, then it buffers digital ink in its internal memory. It transmits any buffered digital ink when it is next within range of a computing system. When the pen's internal memory is full the pen ceases to capture digital ink and instead flashes its error LED whenever the user attempts to write with the pen 101.

Table 4 lists the components of the raw digital ink transmitted from the pen